NCP3-E42 **PATENT APPLICATION**

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:	Examiner: R. Krishnamurthy
NOR-CAL PRODUCTS, INC.	Group Art Unit: 3753
Serial No.: 09/738,194	
Filed: 12/15/2000	April 24, 2003
For: IMPROVED PRESSURE CONTROLLER AND METHOD	San Diego, California 92108

DECLARATION OF David Kruse

Honorable Commissioner of Patents and Trademarks
Washington, D.C. 20231

Dear Sir:

I, David Kruse, declare that:

1. We are the inventors of the invention that is the subject of the instant application for patent;
2. I was asked by Karl M. Steins to prepare a letter regarding the nature of the problems solved by my invention; and
3. Attached hereto is a true and correct copy of the letter which I prepared in support of this Patent Application.

I further declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true, and further that these statements are made with the knowledge that willful false statements and the like are punishable by fine or imprisonment, or both, under Section 1001 of Title 19 of the United States Code, and such willful false statements may jeopardize the above-identified Application and any patent issuing therefrom.

Signed at San Diego, CA By: David Kruse

on this day of April 24, 2003 Print Name: David Kruse.

April 24, 2003

To Whom It May Concern:

Subject: Our Invention that is the subject of U.S. Patent Application No. 09/738,194

Background and Qualifications

See declaration dated November 14, 2002.

Solution to Problems

See declaration dated November 14, 2002.

Distinction from the References

ITEM 14. In his office action, the Examiner has rejected claims based on a combination of two observations:

1. that the prior art cited in pages 2 – 8 of our specification anticipates our method with the exception of having a valve position feedback signal and
2. the disclosure in Lenz' patent that "it is known in the art to use a feedback signal comprising data representing position of a motor drive actuating the valve for the purpose of providing an indication of the position of the valve thereby improving the accuracy of the valve control".

The following are notable about this observation:

1. **Obviousness**: The examiner states, "It would have been obvious to one of ordinary skill in the art at the time the invention was made to have incorporated a position sensor in the prior-art arrangement disclosed by the applicant for the purpose of providing an indication of the position of the valve thereby improving the accuracy of the valve control." It should be noted that position accuracy is not improved simply by providing an <u>indication</u> of position. That is,
   a. this indication of position must be used as a controlled variable in a control loop,
   b. the resolution of the controlled variable must be somewhat greater than the desired accuracy,
   c. to use classical servo design all parameters in the control loop must be linear, and

d. certain characteristics of the mechanical design (backlash, motor & load inertias, coupling stiffnesses, coulomb and viscous frictions, etc) must be constrained to enable the desired performance.

Though it can be simply stated that closed-loop control can significantly improve motion performance (over open-loop control), it doesn't come without a price (in complexity and cost). Development of high performance servomechanisms requires great attention to mechanical design detail that is not required of open-loop systems. Spring-mass systems cause resonances in closed-loop motion controls that require complex frequency compensation. As stated by Electro-Craft[1]:

> In the previous discussion of the motor equation it was assumed that the velocity of all the parts in the motor-load system is identical; i.e., the motor and load may be approximated by a single body. This assumption is not accurate for high-performance servo systems, since the mechanical parts of the system are elastic, and they deflect under torque. Consequently, the instantaneous velocities of various parts are different, and at some frequencies will be in opposite directions. This condition allows the system to store a large amount of mechanical energy, which results in noticeable regular vibrations. This phenomenon is called torsional resonance.

Optimization of these servo-systems entails the use of sophisticated (and costly) frequency spectrum analysis equipment.

Typically, these closed-loop control techniques for achieving high performance motion control were used in association with self-commutating motors (called dc servomotors), where motor control (and position control) was (simply) linearly related to position error. That is, motor speed (torque) is directly and linearly controlled by voltage applied across (or current through) a single pair of terminals. It should be noted that with this type of motor, closed-loop control is not just desirable, but required, to achieve position control.

However, self-commutating motors are not known to be used in the field of our invention. The prior art, as cited in our specification Page 5, Line 13 through Page 6, Line 5 (also reference Per Cederstav's declaration, Motor column), used a motor type referred to as a "stepper motor." The stepper motor achieves position control without the use of closed loop techniques. That is, the motor is moved from one stable position to the next by a series of step commands. These step commands are implemented by sequences of voltages applied across (or currents through) either two (bi-polar drive) or four (uni-polar drive) motor windings. So long as the motor is

operated within specified torque/speed boundaries, knowledge of motor position is maintained. Since motor control is open-loop, the complications associated with cl sed-loop control are avoided. Thus, one who is considered to be of "ordinary skill in the arc" may have no skill in closed-loop controls. The (full-step) step resolution of the most commonly used stepper motors is 200 to 400 steps/revolution (400 to 800 half-steps/revolution). State of the Art in incremental encoders that might be used as feedback provide on the order of 1000 lines/revolution (not that big a difference). Higher position resolution and higher torque was (simply) achieved by inserting a gear reducer between the motor and the valve (never minding the backlash issue of the gear reducer). For example, a 30:1 gear reducer would yield valve position resolution of 1/6000th to 1/24000th revolution of the valve. Thus, the obviousness of *improved pressure control* arising from increased valve position resolution is very doubtful. The better gear reducers' backlash specifications are on the order of 15 arc-minutes (or 1/1500th revolution), or 4 to 16 times the step resolution. Though this degrades position accuracy (compared to step resolution), it is the same for closed-loop control as for open-loop control. The obviousness of *improved pressure control* arising from increased valve actuation speed is also questionable. That is, the time required to change pressure in a chamber filled (or being filled) with gas is usually relatively high compared to motor actuation. Thus, it is not so obvious that closed-loop motion control *improves pressure control* in "semiconductor process equipment." Of course, the degree of pressure control performance is related to the degree of valve control performance. Compare Nor-Cal to its competition by the data presented in Per Cederstav's declaration, columns **Time Open to Closed** and **#Steps of Resolution**.

If it were realized that high performance valve motion control would improve pressure control in semiconductor process equipment, there is still the question of how to accomplish that motion control improvement. Due to electronic commutation required by the stepper motor, it is not obvious how to incorporate closed loop control, since position feedback must be linear for servo control, yet quadrature-sinusoidal and synchronized to rotor position for motor commutation control. Alternatively, proposed change (from the prior art – open-loop stepper motor) to another type of motor and feedback generator (conventionally used in high performance motion control) would not be well received by management (because of the simplicity of the stepper motor).

Field of Invention: The examiner's paraphrase of Lenz' statement calls the feedback signal "data representing p sition of a motor drive." Lenz' statement (Col. 1, lines 60 – 63) is actually "Almost all positioners have a mechanical or an electronic position sensor to provide a position signal which is fed back into a microprocessor-based control section of the positioner," which says nothing of position of a motor drive.

The examiner has made numerous references to the Prior Art as described in our specification. It should be noted that the field of our invention demands a level of performance exceeding that achievable by either pneumatics or hydraulics as means of controlling "throttling valves." Yet, it is clear in examining the Lenz patent that the most common method of valve positioning in that field is pneumatics. Reference Col. 1, Lines 31 – 37; "The actuator provides means for physically positioning the valve and may be electric, hydraulic or pneumatic. Electric actuators have a current signal which drives a motor which positions the valve. Hydraulic actuators have oil filled means for positioning the valve. By far the most common in the process control industry, a pneumatic actuator has a piston or a combination of spring and diaphragm." It is clear that Lenz' reference to an electric motor is purely general (Col. 1, lines 33 – 34 and 48 – 49). Lenz' invention pertains (not to a motor driven actuator) but to a pneumatically driven actuator. Lenz' statement is one to "cover all bases" and is very broad and general. Lenz' Claim 1 states "A valve positioner for providing a control pressure to an actuator diaphragm..." This is clearly not an electric motor driven actuator. Furthermore, the control pressures referred to throughout Lenz' patent are for the pneumatic actuator, not a process pressure as in the case of our patent. Pneumatic and hydraulic actuators are simply too slow to achieve our performance requirements. That is, the field of the invention is different.

2. The value of the method is not simply in improved valve position accuracy. As much can be said for responsiveness (bandwidth), stability (overall performance) and price versus performance. One could cite numerous reasons why inclusion of closed loop motion control was not deemed worth the effort by our competition, but the fact remains it was not (reference Per Cederstav's declaration, Motor Control Technology column).

ITEM 15. In his office action, the Examiner has expressed the opinion that in combination with the prior art and Lenz "the patent to Scholl et al. discloses (Fig. 3 and Col. 3, line 50 – Col. 4, line

16) that it is known in the art t directly couple a motor drive via motor shaft to a valve stem for the purpose f obtaining simplicity, efficiency and cost effectiveness (Col. 4, lines 47 – 49)".

I respectfully beg to differ with the examiner in that Scholl's description is of a rotary motor, coupled to a ball screw whose output shaft moves axially, which in turn is connected to an axially moveable valve stem. Specifically, Col. 3, lines 53 – 55 state "A ball-screw mechanism is provided for converting rotary motion to linear motion." Thus, the motor shaft is not connected directly to the valve stem. Furthermore, it can be deduced that Scholl's claim of "simplicity, efficiency, and cost effectiveness" is at best a subjective one. Furthermore, this statement is taken out of context by the examiner. It does not pertain in any way to geared or direct drive valves, but to the use of electric motors and controls to assist the workhorse hydraulic systems in the movement of heavy equipment (Col. 1, lines 6 – 10).

This also points to the fact that the field of Scholl (as with all the other patents cited by the examiner) is outside the field of our invention. Our patent is in the field of direct process pressure control, not in controlling some hydraulic or pneumatic or other valve. Value to the Caterpillar (heavy equipment) industry has a different meaning than it does to the semiconductor tools industry; as do the terms "price" and "performance." Hydraulic and pneumatic actuators are used in applications whose required bandwidths are much lower than electric motor driven actuators. The issue of "simplicity, efficiency and cost effectiveness" is precisely that (among others) which is subjective and different for Scholl (and Caterpillar Inc.) and Lenz than for Nor-Cal Products, Inc. That is, what is cost effective to one industry may not be cost effective to another. As noted in Per Cederstav's declaration, Nor-Cal's competition (if they had given thought to closed loop motion control) did not feel (for many years) that it was worth researching from a price/performance standpoint.

The examiner's argument that "It would have been obvious to one of ordinary skill in the art at the time the invention was made to have directly connected the motor drive to the valve stem in the method according to the combination of the Prior Art and Lenz et al. for the purpose of obtaining simplicity, efficiency and cost effectiveness as recognized by Scholl et al." shows a simplistic view by the examiner. That is, it sounds like a great idea until one tries to make it actually work. In reality it is **more complex** to achieve high performance closed-loop motion control using direct drive means than it w uld be using

gear reduction means. As taught by our application (Page 5, Line 16 through Page 6, Line 5) the effect of gear reduction increases mechanical advantage; thereby increasing output torque and position resolution. Also, tortional resonance is a much bigger problem in a direct drive servo-system than in a gear-reduced system. Thus, to realize the same performance with a direct drive servo-system as with a gear reduced system:

a. motor position feedback resolution must be increased to achieve the same position accuracy,

b. motor output torque rating must be increased (implying the requirement of a larger motor and/or higher power drivers) to drive a given load,

c. more complex frequency compensation (often at a cost to servo bandwith, responsiveness and system stability).

What one discovers is that without proper attention to detail, the solution falls far short of meeting required performance such as motor torque, position resolution, accuracy, responsiveness, etc. Furthermore, what one quickly experiences is that it's actually simpler to employ open-loop step motor control in combination with a gear reducer (the prior art). Thus, I have a problem with the phrase "obvious to one of ordinary skill in the art." The features of high resolution, high torque, high bandwidth are not simply achievable at a reasonable cost tradeoff. Case in point is that it was only after significant development time that the true value (to our field of interest) of high performance closed loop motion control was appreciated. Now that it's been done and documented, it sounds obvious.

References:

1. "DC Motors, Speed Controls, Servo Systems" an engineering handbook by Electro-Craft Corp. Paragraph 2.3.4 Tortional Resonance

David Kruse